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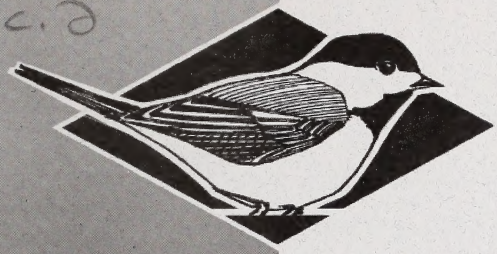

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Prairie Rattlesnake (*Crotalus viridis*) Hibernacula: Monitoring History in Alberta 1987-2002

Alberta Species at Risk Report No. 76

Alberta
SUSTAINABLE RESOURCE DEVELOPMENT

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Prairie Rattlesnake (*Crotalus viridis*) Hibernacula: Monitoring History in Alberta 1987-2002

Kelley J. Kissner
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Alberta Species at Risk Report No. 76

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EXECUTIVE SUMMARY

The prairie rattlesnake is designated as *May Be at Risk* in Alberta due to an accumulation of anecdotal evidence suggesting that prairie rattlesnake populations have declined in the province in recent years. Hibernation sites (hibernacula) of rattlesnakes are used by a number of individuals for 6 to 8 months per year, making this a critical habitat component for this species. In the spring and fall, rattlesnakes typically bask outside hibernacula for a few weeks facilitating their observation. In 2000, Alberta Fish and Wildlife and the Alberta Conservation Association began a long-term project to monitor prairie rattlesnake hibernacula use and population numbers. This project was continued by Alberta Fish and Wildlife in 2001 and 2002. The initial project involved reviewing the Alberta Biodiversity Species Observation Database (BSOD) for locations of hibernacula and conducting ground searches in those areas to verify the occurrence of hibernacula. Interpretation of aerial photos during 2000 and 2001 identified areas that appeared suitable for hibernacula (e.g., slump zones) and focussed ground searches. In 2002, existing locations were monitored and ground searches were conducted in areas that appeared suitable for hibernacula. Prairie rattlesnakes hibernate communally with other snake species, including bullsnakes (*Pituophis catenifer*), garter snakes (*Thamnophis spp.*) and occasionally hognose snakes (*Heterodon nasicus*) allowing den use by these species to be monitored opportunistically. This report has two objectives. First, this report summarizes the results of surveys at rattlesnake hibernacula conducted between 2000 and 2002. Second, this report summarizes historical data on numbers of snakes at hibernacula. Taken together, this information can be used to estimate long-term changes in den use and rattlesnake numbers in Alberta.

In total, 107 potential hibernacula were compiled from data from BSOD, surveys, and a review of the literature. Compiling information from BSOD proved challenging mainly because site locations were vague or imprecise, making it difficult to determine how many hibernacula were in a small geographic location. In addition, a variety of names were given to individual hibernacula making it difficult to determine correspondence among records. Of the 107 hibernacula, 70 were surveyed between 2000 and 2002. Surveys revealed that 43 of these hibernacula were active, 18 were potentially active and nine were inactive or destroyed. Of the 43 active sites, 23 were new hibernacula found during surveys. Locations of new hibernacula have been added to the provincial database. In total, 757 snakes were observed at hibernacula between 2000 and 2002. Typically few individuals were observed at individual sites. The available historical information on rattlesnake numbers at hibernacula indicates that fewer rattlesnakes appear to be using these sites in recent years, suggesting a decline in the prairie rattlesnake population in Alberta. Until more intensive methods for estimating the size of the prairie rattlesnake population in Alberta are used (e.g., mark-recapture techniques), these observations and surveys can be used to inform future status assessments of this species. Recommendations for future research and management of rattlesnakes include the development of a provincial management plan, development and ground-truthing of predictive models to identify denning habitat and other key habitat on the landscape, initiation of intensive monitoring programs that allow population size to be estimated, and the initiation of studies to examine habitat use, genetic diversity among denning populations, and the impact of road mortalities on rattlesnake populations.

1.0 INTRODUCTION

The prairie rattlesnake (*Crotalus viridis viridis*), a subspecies of the western rattlesnake, reaches the northern limits of its range in southern Alberta (Figure 1). This species is designated as *May Be at Risk* in Alberta due to an accumulation of anecdotal evidence suggesting that prairie rattlesnake populations have declined in the province in recent years (Watson and Russell 1997, Alberta Sustainable Resource Development 2001).

During the winter months, prairie rattlesnakes hibernate in dens (hibernacula) that protect them from freezing temperatures. In Alberta, hibernacula are typically distributed along the breaks and coulees of major river drainages in the southeastern portion of the province, including the South Saskatchewan, Red Deer, Bow, Oldman and Milk Rivers. Suitable hibernation sites include stable slump zones, fissures, sinkholes, rocky outcrops, and mammal burrows (Cottonwood Consultants 1986, 1987, Hofman 1991, Watson and Russell 1997, Didiuk 1999, Russell and Bauer 2000, Moes 2001). Depending on ambient temperatures during the spring and fall, snakes may spend between 6 to 8 months in hibernation. Because of the long duration spent in hibernation, hibernacula represent a critical habitat component for rattlesnakes. Many individual rattlesnakes den together in the same site. In addition, individuals typically show high fidelity to a particular site, despite making foraging migrations as far as 25 km from hibernacula (Didiuk 1999). The behaviour of rattlesnakes to den communally and to show high site fidelity may suggest that appropriate over-wintering sites are limited across the landscape. The locations of birthing areas (rookeries) of prairie rattlesnakes tend to be in close association with hibernacula, further highlighting the importance of this habitat to prairie rattlesnake populations.

Rattlesnakes typically bask outside hibernacula for a few weeks in the spring after emerging from hibernation, and in the autumn prior to entering hibernation (Duvall et al. 1985), allowing snakes to be easily observed during this time. In 2000, Alberta Fish and Wildlife and the Alberta Conservation Association began a long-term project to monitor prairie rattlesnake hibernacula use and population numbers using observations of snakes at hibernacula in the spring and fall. The initial project involved reviewing the Alberta Biodiversity Species Observation Database (BSOD) for locations of hibernacula and conducting ground searches in those areas to verify the occurrence of hibernacula (Rose 2001). Many of the records from BSOD included vague information on the locations of hibernacula resulting in only a limited number of these sites being located (Rose 2001). Interpretation of aerial photos during 2000 identified areas that appeared suitable for hibernacula (e.g., slump zones) and focussed ground searches aimed at location of unknown hibernacula (Nicholson and Rose 2001). In 2001, interpretation of air photos and ground searches were continued by Alberta Fish and Wildlife to aid in locating hibernacula. Additionally, numbers of snakes at known hibernacula were also monitored. In 2002, Alberta Fish and Wildlife continued monitoring numbers of snakes using known hibernacula and conducting ground searches in areas that appeared suitable for hibernacula. In all years, additional hibernacula were located by consulting with researches studying prairie rattlesnakes in the province, and by interviewing landowners and leaseholders with land along major river drainages. Prairie rattlesnakes hibernate communally with other snake species, including bullsnakes (*Pituophis catenifer sayi*), garter snakes (*Thamnophis* spp.) and occasionally hognose snakes (*Heterodon nasicus*) allowing den use by these species to be monitored opportunistically.

Figure 1. The range of the prairie rattlesnake (*Crotalus viridis*) in North America (modified from Stebbins 1985).

This report has two objectives. First, this report summarizes the results of surveys at rattlesnake hibernacula conducted between 2000 and 2002. Second, this report summarizes data from the literature and from BSOD on historical numbers of snakes at hibernacula. Observations of snakes at hibernacula made by other observers (e.g., naturalists, researchers) during the formal study are also included. A compilation of historical and recent observations of snakes at hibernacula provides a means of estimating changes in snake numbers at these sites. Until more intensive methods for estimating the size of the prairie rattlesnake population in Alberta are used (e.g., mark-recapture techniques), these observations and surveys can be used to inform future status assessments of this species.

In addition to providing information on prairie rattlesnake populations, identification of hibernacula is important from a land use perspective. Industrial and agricultural activities are particularly intense in the southeastern portion of the range of rattlesnakes in Alberta. Hibernacula of prairie rattlesnakes receive year-round protection under the Wildlife Act, prohibiting the destruction of these sites. Furthermore, the Alberta Fish and Wildlife Division Sensitive Wildlife Species Habitat Protection Guidelines suggest that physical disturbance should be prohibited within 200 m of known hibernacula. Thus, knowledge of the locations of rattlesnake hibernacula is critical to protecting the integrity of the habitat from land use disturbances.

2.0 STUDY AREA

Prairie rattlesnakes occur within the Grassland Region of Alberta. Habitat in this region is mixed-grass prairie. This region is characterized by little precipitation and long, cold winters. The study area for this monitoring project extends over the known range of the prairie rattlesnake within Alberta, with a focus along the major drainages in southern Alberta where most hibernacula are known to occur (Figure 2). Historically, rattlesnakes in Alberta ranged from the United States-Canada border as far north as Trochu and from the Alberta-Saskatchewan border almost to Calgary (Watson and Russell 1997). Recent observations suggest that rattlesnakes are restricted to the southeastern corner of the province east of 112° 53′W and south of 51° 22′N (Watson and Russell 1997). The majority of surveys and ground searches for new hibernacula were conducted along the breaks and coulees of the South Saskatchewan River, north of Medicine Hat.

3.0 METHODS

3.1 Summary of Existing and New Hibernacula

In 2000, a search of BSOD was conducted to summarize locations of prairie rattlesnake hibernacula in Alberta. Records obtained from BSOD included historical and recent locations of hibernacula and also observations of snakes at sites suspected to be hibernacula. Beginning in 2000, ground searches were conducted to determine the existence/persistence of these hibernacula. In addition, aerial photos of the South Saskatchewan River valley between 50° 00′N and 50° 20′N were used to identify potential areas that were likely to contain hibernacula

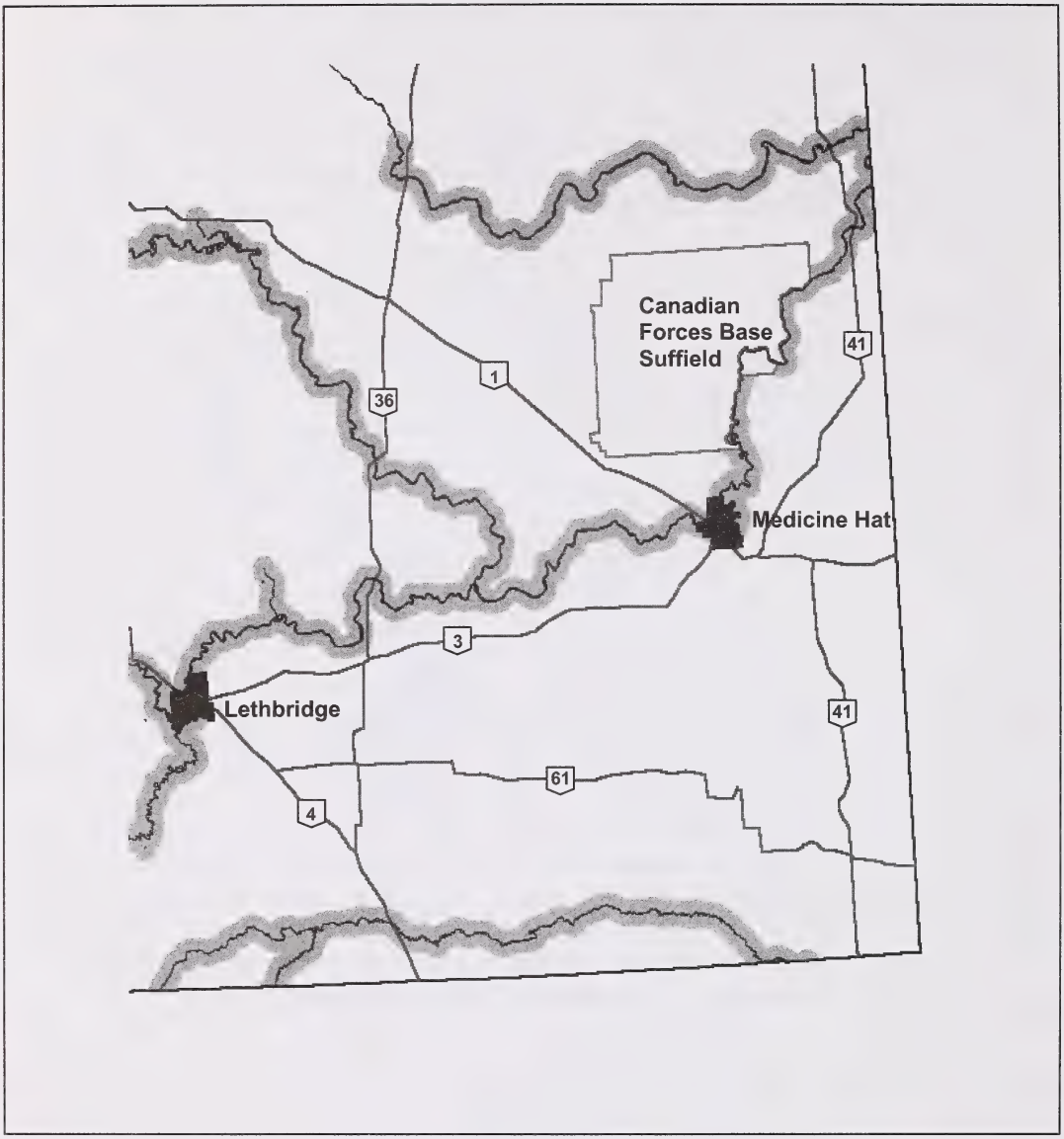

Figure 2. Map of southeastern Alberta. Shaded areas along river drainages indicate approximate areas where searches for hibernacula were conducted.

due to the existence of slump zones in these areas. In the spring of 2001, hibernacula located during 2000 were monitored. In addition, aerial photos of the South Saskatchewan River Valley between approximately 50° 20′N and 50° 50′N were used to identify potential areas likely to contain hibernacula. These areas were searched during the summer of 2001 and any potential hibernacula were searched in the fall of 2001 to verify whether snakes were using these sites. In 2002, den monitoring of existing sites was conducted during April and May and August to October. Searches for new sites were conducted while travelling to existing sites. In all years, additional hibernacula were located by consulting with researches studying prairie rattlesnakes in the province and by interviewing landowners and leaseholders with land holdings along major river drainages.

Upon locating a new or historical site, a GPS location was recorded as either a universal transverse meridian (UTM) coordinate or a geographic coordinate (latitude/longitude) using map datum NAD83. These locations have been added to a map of rattlesnake hibernacula within Alberta. Contact information on the landowner or leaseholder and the ATS location (township, range, section) were also recorded. A number of physical and biophysical attributes and site information were recorded including, number of openings, vegetative cover around the site, slope, aspect, and distance to a variety of disturbances. In addition, a photograph(s) was taken of the site and a description of the access route to the site was recorded. Photographs and site descriptions of hibernacula were taken to facilitate structured repeated monitoring of these sites in subsequent years by different observers. A standardized protocol for locating snake hibernacula is under development (Alberta Sustainable Resource Development, in prep.). This protocol provides copies of datasheets used to collect information at hibernacula.

3.2 Observations of Snakes at Hibernacula

Rattlesnake hibernacula are typically characterized by a number of holes/fissures that allow snakes to enter and leave the sites. During each visit to a hibernaculum, the total number of rattlesnakes seen at/near every opening was recorded. Counts of any other snake species observed at hibernacula were also made. When possible, the relative age of snakes (young of the year, juvenile, or adult) was recorded. Mating observations or evidence of breeding due to the presence of young of the year (neonates) was also recorded. The weather conditions during monitoring were recorded in most cases. This included temperature, percent cloud cover, wind velocity, and precipitation. Wind velocity was measured using an anemometer or estimated using the Beaufort scale (Appendix 1). Other observations (e.g., evidence of predation) were also recorded.

3.3 Data Compilation

In 2003, a search was made of BSOD and of the literature (e.g., reports) to compile all *available* information on locations of hibernacula and of the numbers of snakes observed at these hibernacula. In 1987, Cottonwood Consultant Ltd. summarized historical locations of hibernacula and historical data on numbers of snakes at hibernacula in Alberta (Cottonwood Consultants Ltd. 1987). Hibernacula referenced in BSOD or in reports with only vague information were excluded in some instances (see results). Hibernacula in the National Wildlife

Area within the boundaries of Canadian Forces Base Suffield have been studied for several years by the Canadian Wildlife Service. Observations of snakes at these hibernacula are also not included (A. Didiuk, unpubl. data).

4.0 RESULTS

Compiling data from reports and from BSOD on historical and recent observations of snakes at individual hibernacula proved to be challenging. In a number of instances, individual hibernacula were referenced using different locations. Typically, this resulted from observers using coordinates with different precision (e.g., ATS locations vs. UTM coordinates). Consequently, in some cases, it was difficult to determine whether several observations were made at a single hibernaculum or at two different, but geographically close, hibernacula. Another difficulty in attributing observations to a single hibernaculum resulted from different observers providing unique names or numbers for the sites, resulting in two or more names for a single hibernaculum. Data were only attributed to a single hibernaculum when it was reasonably clear that they were collected from the same site. Based on the results of this compilation, BSOD records for prairie rattlesnakes will be updated to remove any errors and site location names for each hibernaculum will be assigned to reduce confusion. Subsequent investigators will be informed of new protocols and data collection methodologies for future site visits.

In total, the data compilation phase of the project and surveys conducted from 2000 to 2002 identified 107 hibernacula. Of these, 70 were surveyed between 2000-2002. Forty-three sites were confirmed to be active hibernacula and nine sites appear to be inactive or destroyed. Eighteen sites require verification because only one snake was observed during surveys. Of the 43 active sites, five, 15, and three sites were new hibernacula found in 2000, 2001, and 2002, respectively. Locations of new hibernacula have been added to the provincial database. Three sites located in 2000 and five sites located in 2001 are suspected hibernacula based on the presence of a single snake. Presence of rattlesnakes in another year will verify that these sites are used as hibernacula. Of the remaining hibernacula, 29 sites were not monitored due to time restraints on the number of hibernacula that could be visited or because vague information on location of a site made finding it difficult.

During the surveys, 300, 147, and 310 prairie rattlesnakes were observed at hibernacula in 2000, 2001, and 2002, respectively. Table 1 indicates the numbers of rattlesnakes observed at 37 individual hibernacula for which several years of monitoring were conducted. When available, historical data on numbers of snakes observed at these sites are also provided. Although there are a fairly large number of hibernacula in the province, Table 1 indicates that small numbers of snakes were observed at many of these hibernacula during surveys. The available historical information on rattlesnake numbers indicates that fewer rattlesnakes appear to be using many of these sites in recent years.

Table 1. The number of prairie rattlesnakes (*Crotalus viridis*) observed at 37 hibernacula. Values obtained for 2000-2002 represent the maximum number of snakes observed during a single visit. Historical data reflects numbers of rattlesnakes observed prior to 1990. Ranges indicate numbers of snakes observed across years. Unknown refers to sites that were not known in that year(s). Hibernacula that were not survey during 2000-2002 are designated by nm.

Den	Historical*	1990's	2000	2001	2002
1	"thousands"	unknown	0	0	0
2	"hundreds"	0	0	nm	nm
3	"tens"	0	0	nm	nm
4	"tens"	0	0	nm	nm
5	5-20	50	1	3	15
6	unknown	142	1	nm	nm
7	unknown	**	2	1	1
8	unknown	unknown	2	nm	1
9	unknown	**	3	12	5
10	unknown	unknown	5	nm	3
11	30	1-3	8	nm	nm
12	unknown	124***	10	15	34
13	unknown	unknown	11	5	15
14	unknown	unknown	12	11	4
15	less than 100	35-40	75	nm	nm
16	60	7-86	120	nm	90
17	"scores"	1-11	4	0	12
18	"scores"	1-18	10	23	18
19	unknown	20	nm	0	4
20	"tens"	nm	nm	2	4
21	present	nm	nm	2	8
22	10-25/day	nm	nm	4	nm
23	"tens"	nm	nm	13	20
24	unknown	unknown	unknown	1	0
25	unknown	unknown	unknown	1	1
26	unknown	unknown	unknown	1	1
27	unknown	unknown	unknown	1	11
28	unknown	unknown	unknown	2	0
29	unknown	unknown	unknown	2	2
30	unknown	unknown	unknown	2	8
31	unknown	unknown	unknown	3	6
32	unknown	unknown	unknown	6	7
33	unknown	unknown	unknown	11	1
34	unknown	unknown	unknown	12	0
35	unknown	unknown	unknown	unknown	4
36	unknown	unknown	unknown	unknown	11
37	unknown	unknown	unknown	unknown	13

*Cottonwood Consultants Ltd. (1987), ** A. Didiuk (unpubl. data), ***Powell et al. 1998

Few other snake species were observed at dens with rattlesnakes during surveys (Table 2). No hognose snakes or red-sided garter snakes were observed at any den site.

Table 2. The total number of other snake species observed at rattlesnake hibernacula in 2000-2002.

Species	2000	2001	2002
Bullsnake	8	27	11
Wandering Garter Snake	19	9	24
Plains Garter Snake	3	2	1

5.0 DISCUSSION

A compilation of data on hibernacula within Alberta and surveys for new and existing hibernacula during 2000 to 2002 revealed 107 potential hibernacula within southern Alberta. Surveys of 70 of these sites revealed 43 active, 18 potentially active, and nine inactive hibernacula with a total of 757 snakes observed at active or potentially active sites across years. Although a large number of hibernacula exist within the province, few individuals tend to use these sites. The available historical data suggests that large numbers of rattlesnakes used some of these sites in the past. Recent surveys revealed small numbers of rattlesnakes at many of these dens, supporting a decline in the prairie rattlesnake population in Alberta. For example, there appears to have been a large decrease in the number of rattlesnakes using den 12. This hibernaculum is located within 10 meters of a gravel road with high traffic intensity due to oil and gas development. In contrast, the number of rattlesnakes at dens 15 and 16 has increased or remained relatively stable compared to historical numbers. These sites are known to be protected by the leaseholders. Without the resources available to undertake an intensive mark-recapture study to determine population size, den monitoring provides the best way to monitor size and trends of rattlesnake populations.

Each year additional hibernacula are located during surveys, allowing for better estimates of the population size of prairie rattlesnakes in Alberta. During the three years of surveys reported here, 23 new hibernacula were located. These sites now receive year-round protection under the Wildlife Act. In addition, Alberta Sensitive Wildlife Species Habitat Protection Guidelines attempt to protect hibernacula by suggesting that disturbance within 200 metres of these sites should be prohibited.

Few other snakes were observed at dens with rattlesnakes from 2000 to 2002. This may reflect that large numbers of these species do not den with rattlesnakes, that these species enter hibernation earlier (or later) than rattlesnakes, or that these species do not bask near dens for very long in the spring and fall precluding their observation during surveys. The bullsnake is considered sensitive in Alberta due to perceived declines in its population size in recent years (Alberta Sustainable Resource Development 2001, Kissner and Nicholson 2003). Few observations of this species during this study may reflect declining numbers of this species in Alberta. Bullsnakes are known to den in conspecific groups in some areas of the province (J. Wright, unpubl. data) and may spend less time basking at hibernacula than rattlesnakes (C. Shewchuk, pers. comm.), possibly reducing numbers of bullsnakes observed during rattlesnake

surveys. Hibernacula used by bullsnakes are protected from 30 September to 1 April when snakes are hibernating. Few observations of bullsnakes during surveys and the behaviour of rattlesnakes and bullsnakes to co-hibernate may suggest that bullsnake hibernacula should receive year round protection. Until formal studies of bullsnakes are undertaken, monitoring of rattlesnake hibernacula will continue to provide some information on bullsnake populations in Alberta. Garter snakes are known to hibernate in natural and artificial (e.g., around wells or house foundations) hibernacula. Few observations of garter snakes may simply reflect their ability to use a wider variety of hibernacula than rattlesnakes.

6.0 RECOMMENDATIONS FOR FUTURE RESEARCH AND MANAGEMENT

6.1 Provincial Management Plan

In 2000, the Alberta Endangered Species Conservation Committee reviewed the available literature and data on prairie rattlesnakes in Alberta. Based on the lack of detailed information on population size and trends, a designation of 'data deficient' was given to this species. Recommendations by the ESCC included allocation of resources to collect information on population size, distribution, and trends of rattlesnakes in the province. These recommendations will be included in a provincial management plan for prairie rattlesnakes that is currently under development. Recommendations by the ESCC in 2000 also resulted in rattlesnake hibernacula being protected year-round and their being maintained as a 'non-game' species under the Wildlife Act. A reassessment of the status of prairie rattlesnakes by the ESCC will occur by 2005.

6.2 Population Size Monitoring

Baseline data on population size and other parameters is needed to determine whether rattlesnakes in Alberta are declining. This information is also needed to inform future provincial (ESCC) and national (COSEWIC) status assessments of rattlesnakes. Counts of snakes at hibernacula in this study (data herein and Rose 2001) and other studies in the province (Hofman 1991, Moes 2001, Ernst 2002) provide a coarse method for monitoring prairie rattlesnake numbers in Alberta. However, this method does not allow individual snakes to be identified. Consequently, snakes observed at repeated visits to a site may be the same individuals. A more accurate method to estimate population size of prairie rattlesnakes in Alberta will require mark-recapture techniques. These techniques allow for an estimation of population size using the number of marked and unmarked snakes captured over a number of sampling periods. Marking of snakes is most easily accomplished via scale-clipping or implantation of passive integrated transponder (PIT) tags. Passive integrated transponder tags are small glass-encased microchips that are uniquely alphanumerically coded and can be read with a hand-held scanner. Although more expensive than scale-clipping, PIT tags are easily read and last the lifetime of the individual. Furthermore, a scanner mounted on a telescopic handle allows individuals to be identified without the need to intensively handle snakes.

6.3 Identification of Denning and Rookery Habitat

Rattlesnake hibernacula are critical habitat features for prairie rattlesnakes. Once located, the Wildlife Act prohibits destruction of hibernacula and provincial guidelines suggest that disturbance within 200 m of these sites should be prohibited. Consequently, the location of as many hibernacula as possible is critical to ensure that the integrity of these sites is maintained and, ultimately, to conserve rattlesnake populations within Alberta.

Ground searches for rattlesnake hibernacula are time consuming and laborious. Predictive models that identify where hibernacula should occur on the landscape provide a means of focussing these searches. Recently, Nicholson and Rose (2001) used air photo interpretation to identify areas more or less likely to contain hibernacula. Ground searches of these areas showed that this model was reasonably successful in identifying habitat more likely to contain hibernacula. Development of GIS-based models for identifying overwintering habitat is currently underway (Fast and Gates 2002). Once developed these methods will require ground-truthing and potential refinement.

After emergence, gravid (pregnant) female rattlesnakes migrate to birthing areas (rookeries) where they remain until they give birth. Individual females may give birth at the same rookery site during more than one reproductive season and several females may use the same rookery site (Gannon and Secoy 1985). It is unknown how the destruction of rookery habitat affects recruitment into rattlesnake populations. Identification and protection of rookery habitat may be critical for conserving rattlesnake populations in Alberta.

Radio-telemetry, although time consuming and laborious, is another method to locate new hibernacula and rookery sites. To locate new hibernacula, snakes can be captured during the summer months when away from their hibernacula, implanted with a radio-transmitter, and then followed back to their hibernacula. To locate rookery sites, gravid females can be captured at hibernacula after emergence, implanted with a radio-transmitter, and followed to rookery sites.

6.4 Determination of Habitat Use by Rattlesnakes and of the Influence of Habitat Connectivity/Fragmentation on Gene Flow Among Denning Populations

Little information is available on the specific habitat requirements of rattlesnakes across their range in Alberta. Sampling techniques (e.g., trapping) in different habitats can be used to show the presence or absence of rattlesnakes in a habitat, but provides little information about the time individuals spend in habitats or about what activities are carried out in these habitats. Didiuk (1999) used trapping methods to investigate the presence and absence of rattlesnakes in 11 habitat types. Although rattlesnakes were found in all habitat types, they were predominately associated with habitats in the Middle Sand Hills region and upland habitat. Radio-telemetry can also be used to investigate habitat use of snakes. This method allows individual snakes to be followed throughout the active season. Consequently, this method provides data on time budgets in certain habitats and what activities are carried out in these habitats, in addition to information on which habitats snakes use.

Increasing industrial and agricultural activity in southeastern Alberta has resulted in much of the native habitat for prairie rattlesnakes becoming fragmented. Whether different types of land use activities impede or change snake movements is not known. As habitat becomes more fragmented, populations may become smaller and more isolated precluding mating opportunities among individuals from different populations. Restricted gene flow may lead to inbreeding depression and genetic drift, both of which can lead to local extinctions (Blouin-Demers and Weatherhead 2002). Studies that examine snake movement and genetic diversity among denning populations are needed to determine how land use activities impact gene flow.

6.5 Investigation of the Effect of Road Mortality on Rattlesnake Populations

Increasing agricultural and oil and gas activity in Alberta has led to an increase in the number of roads intersecting rattlesnake habitat and an increase in traffic intensity on these roads. In addition to the loss of habitat due to road construction, a large number of snakes are killed on roads in Alberta as they disperse from dens to upland habitat to forage. Didiuk (1999) examined road mortality of snakes in the National Wildlife Area within Canadian Forces Base Suffield. Of the 249 snakes observed on roads during their study, 101 (41%) were dead. Clearly, road mortality is a factor that may limit rattlesnake and other snake populations. Further study using standardized methods to examine timing, location, and number of mortalities and how these interact with traffic intensity and road type, is needed to determine the impact road mortality has on snake populations and to inform mitigation measures (e.g., snake crossing signs). Currently, Canadian Forces Base Suffield and EnCana have implemented a traffic management strategy in order to decrease the number of road-killed snakes.

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Appendix 1. The Beaufort scale of wind velocity
(World Meteorological Organization 1970)

Force	Description	Wind Speed (km/h)	Possible Effects
0	Calm	0	Chimney smoke rises straight up
1	Light air	3	Smoke drifts gently
2	Light breeze	9	Leaves rustle, wind felt on face
3	Gentle breeze	15	Leaves and twigs on trees move
4	Moderate wind	25	Dust and paper raised from ground
5	Fresh wind	35	Small trees start to sway
6	Strong wind	45	Large branches move
7	Near gale	56	Whole trees sway
8	Gale	68	Difficult to walk into wind
9	Severe gale	81	Branches and slates blown off
10	Storm	94	Houses damaged, trees uprooted
11	Severe storm	110	Serious damage to houses
12	Hurricane	118	Widespread damage

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